



(22) Date de dépôt/Filing Date: 2011/09/12
(41) Mise à la disp. pub./Open to Public Insp.: 2012/05/12
(45) Date de délivrance/Issue Date: 2016/11/29
(62) Demande originale/Original Application: 2 751 948
(30) Priorité/Priority: 2010/11/12 (US12/945,024)

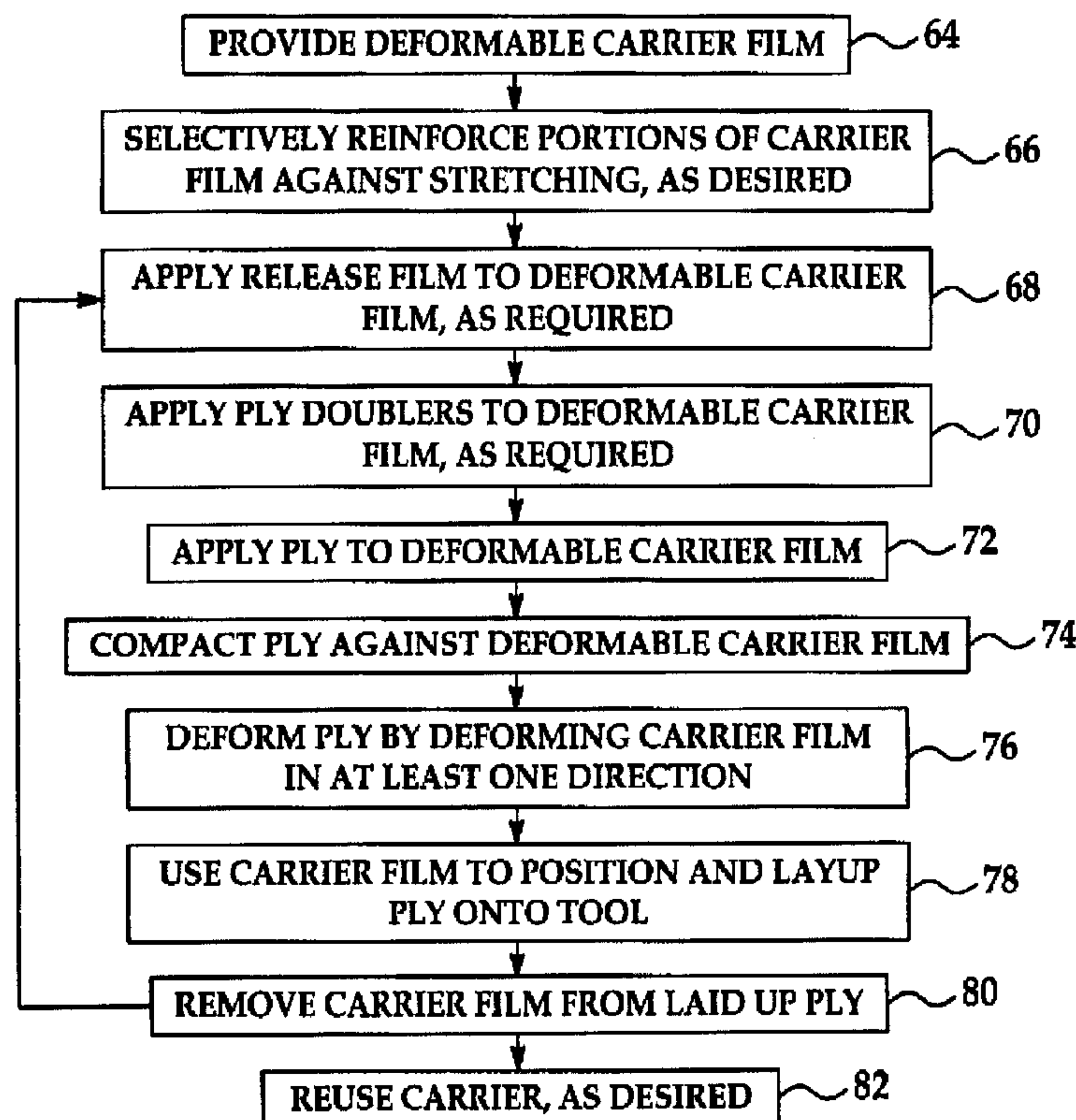
(51) Cl.Int./Int.Cl. *B29C 70/20* (2006.01),
B29C 71/00 (2006.01)

(72) Inventeurs/Inventors:
HAWKINS, ROBERT D., US;
WILLDEN, KURTIS S., US;
MODIN, ANDREW E., US;
DEPASE, EDOARDO, US;
GLAIN, MICHAEL, US;
MUSSI, BENJAMIN ADAM, US;
KISMARTON, MAX U., US

(73) Propriétaire/Owner:
THE BOEING COMPANY, US

(74) Agent: SMART & BIGGAR

(54) Titre : METHODE D'ASSEMBLAGE DE COUCHES PREIMPREGNEES SUR DES OUTILS MOULES A L'AIDE D'UN SUPPORT PELLICULAIRE DEFORMABLE
(54) Title: METHOD OF LAYING UP PREPREG PLYS ON CONTOURED TOOLS USING A DEFORMABLE CARRIER FILM



(57) Abrégé/Abstract:

A method of deforming a prepreg fiber ply. The method involves laying up a unidirectional prepreg fiber ply on a film and deforming the film with the ply thereon.

ABSTRACT OF THE DISCLOSURE

A method of deforming a prepreg fiber ply. The method involves laying up a
5 unidirectional prepreg fiber ply on a film and deforming the film with the ply thereon.

METHOD OF LAYING UP PREPREG PLIES ON CONTOURED TOOLS USING A DEFORMABLE CARRIER FILM

TECHNICAL FIELD

5

This disclosure generally relates to processes for fabricating composite structures, and deals more particularly with a method of handling and laying up composite plies, especially on contoured tools.

10

BACKGROUND

During layup of prepreg plies over a tool, it is sometimes necessary to closely conform the ply to curves, contours and/or features of the tool in order to assure that the layup is substantially free of voids, wrinkling and/or buckling. Known techniques
15 for conforming plies to curved tool surfaces involve darting, cutting and/or splitting the ply during the layup process, and/or extensive hand sweeping to conform the ply to contoured tool surfaces. These techniques may be time consuming and/or may provide undesirable mechanical strength of the cured part. Another solution to the problem involves using relatively narrow slit prepreg tape in order to more closely
20 conform the composite material to contoured tool surfaces. However the use of slit tape may increase material costs and reduce production rate since laying down slit tape may be more time consuming.

Accordingly, there is a need for a method of laying up a composite ply over a
25 contoured tool that allows the ply to be deformed as it is applied to the tool in order to more closely conform the ply to tool contours while the ply remains accurately positioned. There is also a need for a method of handling and transporting ply material which allows the material to remain stable during transport and layup.

SUMMARY

The disclosed embodiments provide a method of supporting, positioning and deforming a prepreg ply while it is being conformed to simple or complex shapes, contours and features of a tool. The method utilizes a deformable carrier film to support the ply during the layup process in order to prevent the ply from wrinkling and/or buckling as it is being laid up. Use of the carrier film allows the prepreg ply to be accurately positioned and uniformly deformed as needed to conform to contoured tool surfaces. The carrier film may also be used to stabilize the composite ply during handling and transporting. The method may eliminate the need for the use of slit tape, as well as extensive hand working, darting, cutting, and splitting during ply layup. The method may also increase laydown rates of composite material and may facilitate automation of the layup process. Further, the method may improve the accuracy of ply boundaries and provide more uniform deforming of ply material when required, resulting in improvements in both the strength and appearance of cured composite parts.

The disclosure describes a method of deforming a prepreg fiber ply. The method involves laying up a unidirectional prepreg fiber ply on a film and deforming the film with the ply thereon.

Deforming the film may include stretching the film in a direction traverse to the orientation of the fibers in the ply.

The method may also involve restraining at least a portion of the film against deformation.

Restraining at least a portion of the film against deformation may be performed by reinforcing the portion of the film.

The disclosure also describes a prepreg fiber ply deformed by the method above.

5 **BRIEF DESCRIPTION OF THE ILLUSTRATIONS**

FIG. 1 is an illustration of a plan view of a composite prepreg ply held on a deformable carrier film, prior to deforming.

10 FIG. 2 is an illustration of a perspective view of a corner of the carrier film viewed from the direction shown as '2' in FIG. 1.

FIG. 3 is an illustration of a view of the ply in direction shown as '3' in FIG. 2.

15 FIG. 4 is an illustration of a plan view of the carrier film showing several courses of composite material having been applied to the film.

FIG. 5 is an illustration of the area designated as '5' in FIG. 4.

20 FIG. 6 is an illustration similar to FIG. 1 but showing the carrier film and the ply having been deformed.

FIG. 7 is an illustration similar to FIG. 2 showing a corner of the ply and the carrier film after deforming.

25

FIG. 8 is an illustration of a sectional view of the deformed ply viewed in the direction shown as '8' in FIG. 7.

FIG. 9 is an illustration of a plan view of a **90** degree ply on a carrier film that has been deformed to stretch the ply into a fan shaped pattern.

FIG. 10 is an illustration of a plan view of a carrier film having a **45** degree ply
5 compacted thereon, prior to deforming.

FIG. 11 is an illustration similar to FIG. 10 but showing the carrier film and ply having been deformed in orthogonal directions.

10 FIG. 12 is an illustration of a sectional view of a carrier film having a ply, a ply doubler and a release film strip applied thereto.

FIG. 13 is an illustration of a carrier film prior to deforming which includes a substantially non-deformable area containing a fiber reinforcement.

15 FIG. 14 is an illustration similar to FIG. 13 but showing portions of the carrier film having been deformed.

FIG. 15 is an illustration of a plan view of a carrier film having an isolated area
20 of reinforcement therein.

FIG. 16 is an illustration of a sectional view taken along the line **16-16** in FIG. **15**.

25 FIG. 17 is an illustration of a carrier film having an integrally formed embossment.

FIG. 18 is an illustration of a flow diagram of a method of laying up a composite structure using a deformable carrier film for ply layup.

FIG. 19 is an illustration of a perspective view of a composite stiffener.

FIG. 20 is an illustration of diagrammatic views showing the steps of a method
5 for laying up composite plies using the deformable carrier film to form the stiffener section shown in FIG. 19.

FIG. 21 is an illustration of a flow diagram of aircraft production and service methodology.

10

FIG. 22 is an illustration of a block diagram of an aircraft.

DETAILED DESCRIPTION

15 Referring first to FIGS. 1, 2 and 3, a ply 30 of composite material is held in face-to-face contact on a carrier film 32 to form a carrier-ply assembly 34. The carrier film 32 may be used to transport the ply 30 and/or to apply the ply 30 to a tool (not shown) during a layup process for producing a composite part layup (not shown). In the example illustrated in FIGS. 1-3, the prepreg ply 30 includes unidirectional
20 reinforcing fibers 40 having a 90 degree orientation, however other plies (not shown) in the part layup may have other fiber orientations based on a predefined ply schedule.

The fibers 40 are pre-impregnated with a suitable polymer resin 42 which acts
25 as a matrix to hold the fibers 40 in the desired orientation following curing. The resin 42 may be a visco-elastic resin. The composite ply 30 has a length L_1 and a width W_1 prior to being deformed during the layup process, as will be described in more detail below. The ply 30 is adhered to the carrier film 32 by the tackiness of the uncured resin 42 in the ply 30, however additional tackifiers may be used to provide the

necessary adherence between the ply **30** and the carrier film **32**. Following placement of the ply **30** on the carrier film **32**, the ply **30** may be compacted against the carrier film **32** to assure that the ply is substantially free of buckling, wrinkles or other irregularities.

5

The ply **30** may be placed on the carrier film **32** so as to leave one or more edge margins **36**, **38** on the film **32** around the ply **30** to facilitate handling of the film **32** and/or attachment of hardware or equipment (not shown) to the film **32** that may be used to deform, manipulate and/or hold the carrier film **32** during the layup process. As will be discussed below, once compacted on the carrier film **32**, the ply-carrier film assembly **34** can be deformed to fit different contours and shapes of a tool (not shown). The carrier film **32** allows for controlled and uniform or non-uniform deforming of the resin **42**, and may also be used only as a carrier for transporting the prepreg ply **30** from an offline layup station (not shown) to the layup tool (not shown). As used herein, “deform” and “deforming” refer to stretching and/or shearing of a ply material in one or more directions, including simple and compound curves, and within one or more planes.

The carrier film **32** may be deformed in at least one direction, which in the illustrated example, is along an X axis **44**, transverse to the orientation of the fibers **40**. The carrier film **32** may comprise, for example and without limitation, a latex rubber or similar natural or synthetic deformable material having a thickness suitable for the application. The carrier film **32** material may be an elastic material that returns substantially to its original size and shape following deforming. During the layup process, the ply **30** may be deformed by grasping the film at the opposite edge margins **38** and pulling film **32** in opposite directions indicated by the arrows **46**, substantially along the X axis **44**.

Prior to the ply **30** being deformed, the fibers **40** may have an inter-spacing d_1 . The visco-elastic resin **42** (FIG. 3) yields when deformed in a direction perpendicular to the fiber direction (in this case, the Y axis **45**), thereby allowing the fibers **40** to slip or shear substantially simultaneously in a direction parallel to the fiber direction, i.e. along the X axis **44**, which permits the prepreg ply **30** to conform to the contours of a layup tool (not shown).

Referring to FIGS 4 and 5, the ply **30** may be applied to the carrier film **32** by placing a plurality of individual courses **48a**, **48b**, **48c** of unidirectional tape on the film **32**, in side-by-side, substantially parallel and abutting relationship either by hand or by using automated fiber placement equipment (not shown). Depending on the application and the particular materials being used, the edges **50** of the courses may overlap slightly or may form gaps **G** between the courses **48**. Deforming of the carrier film **32** may be used to control the size of the overlap or gap **G** between the courses **48** during layup of the ply **30** on a tool (not shown). Furthermore, the carrier film **32** may be used to change the grade of a prepreg material used to form the ply **30**. For example, the grade of a prepreg material may be changed by uniformly deforming the material to a desired grade. Changing the grade of a prepreg material in this manner using the carrier film **32** may be useful in producing interleaved doublers that may reduce part weight, and/or material costs.

FIGS. 6, 7 and 8 illustrate the ply **30** following deforming along the X axis **44** in the direction of the arrows **46** in FIG. 1. From FIG. 6 it can be seen that while the width W_1 of the ply **30** remains substantially the same, the ply **30** has been deformed to a greater length L_2 as a result of the deforming of the carrier film **32**. Deforming of the carrier film **32** effectively deforms the **42** resin in the ply **30** which results in an increase in the spacing between the reinforcing fibers to a dimension d_2 which is greater than d_1 . Deforming the ply **30** in this manner may allow the ply **30** to better conform to contours and other features of a tool surface (not shown) during the layup

process, and may stabilize the ply material during layup. The carrier film **32** may prevent the prepreg ply **30** from splitting, wrinkling and/or buckling as it is being formed over a tool (not shown), and may allow the ply **30** to be precisely positioned on the tool during the layup process. It should be noted here that generally, when

5 deforming a **90** degree ply **30** as described above in connection with FIGS. 1-8, the fibers **40** may be expected to deform substantially uniformly along the X axis **44**. However, when deforming non-**90** degree plies **30**, the fiber deformation may not be uniform. For example, when deforming a **0** degree ply **30** (not shown) in the direction of the X axis **44**, the fibers **40** near the ends **55** (FIG. 6) of the ply **30** may shear at an

10 angle (not shown) relative to the fibers **40** near the center **57** of the ply **30** which retain their **0** degree orientation. This shearing effect may occur gradually, growing increasingly from the center **57** toward the ends **55**. Compensation for this shearing deformation may be achieved by cutting the ends **55** of the ply **30** at a pre-selected angle (not shown). When deforming a **45** degree ply **30**, both shearing and

15 stretching of the fibers **40** may occur.

FIG. 9 illustrates the use of the carrier film **32** to deform a **90** degree ply **30** into a radial or fan-like pattern **65** within a single plane, wherein the fiber directions are shown in solid lines. Although not shown in the Figure, this same radial pattern

20 **65** may be deformed into other planes.

FIGS. 10 and 11 illustrate a prepreg ply **30** having a **45** degree fiber orientation which has a width W_1 and a length L_1 prior to deforming as shown in FIG. 9. In this example, the carrier film **32** is deformed along orthogonal X and Y axes **44**,

25 **45**, causing the ply **30** to be likewise deformed to both a greater length L_2 . Stretching of the film **32** along the Y axis results in a change in the orientation angle of the fibers **40** to some angle Θ less than **45** degrees. Although the ply examples shown in FIGS. 1-10 are shown being deformed along single axis or two orthogonal axes **44**, **45**, the ply **30** may be deformed in other directions and within other planes,

depending on the requirements of the application and the geometry of the tool (not shown) to which the ply **30** must be conformed. Moreover, as will be discussed below, it may be possible to deform only one or more portions of the carrier film **32** so that only corresponding portions (not shown) of the ply **30** are deformed during layup process.

In some applications, it may be possible to use the carrier film **32** to pre-position and place additional items of a layup assembly on a tool (not shown), such as without limitation, doublers, release films, and caul plates, along with the ply **30**.

For example, FIG. **12** illustrates a ply **30** placed on a carrier film **32** in which a composite doubler **54** is sandwiched between the ply **30** and the carrier film **32**. Similarly, a strip **56** of release film is sandwiched between the ply **30** and the carrier film **32** along the edge margin **36** on the film **32** which may aid in releasing and peeling the carrier film **32** away from the laid up ply **30**. Thus, in this example, during the layup process, use of the carrier film **32** allows the ply **30**, the doubler **54** and the release film strip **56** to be precisely positioned relative to each other, and to be laid up over a tool (not shown) in a single step.

As previously mentioned, it may be possible or desirable in some applications to deform only a portion of the ply **30** during the layup process. Deforming of the carrier film **32** can be tailored to selectively constrain the elasticity of the ply carrier **32** using any of several techniques that suit part geometry and forming requirements. FIG. **13** illustrates a carrier film **32** having a section **32c** that includes a reinforced portion **58** which resists deforming as the film **32** is being deformed during the layup process. In this example, the reinforcement of the film portion **32c** is achieved by impregnating unidirectional fibers **60** into the carrier film **32**, oriented in the direction that the film **32** is to be deformed, which in this example, is along the X axis **44**.

Prior to deforming, carrier film has a length L_1 and the reinforced portion **32c** has a width R_1 as shown in FIG. **13**. When the carrier film **32** is deformed along the X axis **44**, which corresponds to the axial direction of the fibers **60**, the fibers **60** do not deform substantially, consequently the width R_1 of the reinforced section **32c** remains the substantially same while the overall length of the carrier film **32** deforms to L_2 as a result of the non-reinforced sections **32a**, **32b** of the film **32** on each side of the reinforced section **32c** being allowed to deform. It may also be possible to employ a reinforcement in the reinforced section **32c** which allows some degree of deforming of the film **32**, but less than other, non-reinforced areas of the film **32**. The reinforced portion **32c** may comprise, for example and without limitation, cross stitching (not shown) in the film **32**. Depending on the type of reinforcement that is used, the width W of the reinforced portion **32c** may or may not become more narrow when the film **32** is stretched.

In the case of the example shown in FIGS. **13** and **14**, the reinforced area **58** is centrally located within the carrier film **32** and extends across its entire width W . FIG. **15** illustrates an example in which the reinforced area **58** is spaced inwardly from the edge margins **36**, **38** of the carrier film **32** and is disposed off-center within the area of the film **32**. As in the example shown in FIGS. **13** and **14**, the reinforced area **58** shown in FIG. **15** also may incorporate reinforcing fibers **60** (see FIG. **14**) into the carrier film **32** which may be unidirectional or multi-directional. For example, the fibers **60** may be woven together and incorporated into the film **32** in a manner that resists deforming in two orthogonal directions, e.g. along the X and Y axes **44**, **45**, that correspond to the orientations of the reinforcing fibers. Similarly, fibers **60** may be placed in additional orientations, e.g. **45** degree orientations, to resist deforming of the film **32** within the reinforced area **58** in other directions. While the reinforced area **58** is shown as being generally square in shape, a variety of other shapes are possible.

Other reinforcing techniques to prevent or reduce local deforming of the film **32** are possible. For example, as shown in FIG. **16**, the substantially non-deformable, reinforced area **58** of FIGS. **13**, **14** and **15** may be achieved by increasing the thickness T_1 of a carrier film to a thickness T_2 in the area **58** of reinforcement. FIG. **17** illustrates another technique for achieving the desired reinforcement, in which the carrier film **32** includes embossed dimples **62** in a desired pattern **63**, in this case, diamonds that resist deforming in one or more directions. In some applications, it may be desirable to employ more than one of the above described techniques to achieve substantially non-deformable areas **58**. For example, and without limitation, a combination of embossed dimples **62**, increased film thickness T_2 and reinforcing fibers **58** may be used. It may also be possible to use one or more of the above reinforcement techniques to achieve differing degrees of film elongation in differing regions of the carrier film **32**.

Attention is now directed to FIG. **18** which broadly illustrates the steps of a method of laying up plies to form a composite part using the deformable carrier film **32** previously described. Beginning at **64**, a deformable carrier film **32** is provided having a size and shape suitable for the application and the plies **30** to be laid up. At **66**, portions of the deformable carrier film **32** may be reinforced, as desired. At **68**, a release film **56** (FIG. **12**) may be applied to the deformable carrier film **32**, as required, to aid in the removal of the carrier film **32** from the ply **30** following layup. At **70**, one or more ply doublers **54** (FIG. **11**) or other materials may be applied to the deformable carrier **32**, as desired.

At **72**, a prepreg ply **30** is applied to the deformable carrier either manually, or using automated equipment to lay down courses **49** (FIG. **4**) of prepreg material in side-by-side, possibly substantially abutting relationship on the carrier film **32**. The ply **30** is laid up on the carrier film **32** in a reversed, mirror image-like fashion such that the left and right of the ply **30** are reversed. By reversing the ply **30** on the film

32, the ply 30 will have the proper orientation when transferred from the film 32 to a tool 90 (see FIG. 19). At 74, the ply material, including any doublers and/or release films are compacted against the deformable carrier film 32. This compaction may be performed mechanically with a hand sweep (not shown) or using a vacuum either
 5 with or without the application of heat. At 76, the carrier film 32 is deformed in at least one direction, thereby deforming the ply 30 to the desired shape and/or dimensions best suited for layup on the tool 90, including the shape and topography of the tool 90. At 78, with the ply 30 located on the film 32, and positioned between film 32 and the tool 90, the carrier film 32 is used to position and layup the ply 30
 10 onto a tool 90 (see FIG. 19). At 80, following layup of the ply 30 onto the tool 90, the carrier film 32 is removed, as by peeling it away from the laid-up ply 30. At 82, the carrier film 32 may be reused, if desired, or discarded. Steps 68-80 may be repeated until all of the plies 30 of the part layup have been laid up.

15 FIG. 20 diagrammatically illustrates the steps of the layup method shown in FIG. 18, in which a curved stiffener 100 shown in FIG. 19 having a L-shaped cross section and radius of curvature R is laid up on a curved tool 90. The tool 90 includes two contiguous, curved tool surfaces 90a, 90b for respectively forming a web 100a and a curved flange 100b of the stiffener 100 shown in FIG. 19. As shown at 84,
 20 courses 48 of unidirectional prepreg material are laid down side-by-side on a deformable carrier film 32 to form a completed 90 degree ply 30 shown at 86. The completed ply 30 is then compacted onto the film 32, following which at 88, the film 32 is then stretched and deformed radially as shown by the arrows 87 to generally match the curvature of the tool surface 90a. As shown at 89, the ply 30 is deformed
 25 into a fan shape and placed onto the tool surface 90a using the film 32 to form the curved web 100a of the stiffener 100. The carrier film 32 and a peel ply (not shown) may then be removed from the partially formed ply 30. With the carrier film 32 having been removed, the ply 30 is then formed down over the tool surface 90b to form the flange 100b of the stiffener 100. While the above example illustrates the use of the

carrier film **32** to form plies along curves in a single plane, the carrier film **32** may also be used to form plies over tools (not shown) having compound curved surfaces, joggles, etc.

5 Referring next to FIGS. **21** and **22**, embodiments of the disclosure may be used in the context of an aircraft manufacturing and service method **102** as shown in FIG. **21** and an aircraft **104** as shown in FIG. **22**. During pre-production, exemplary method **102** may include specification and design **106** of the aircraft **104** and material procurement **108**. During production, component and subassembly manufacturing
10 **110** and system integration **112** of the aircraft **104** takes place. During step **110**, the disclosed method and apparatus may be employed to fabricate composite parts such as fuselage frame sections and stiffeners which are then assembled at step **112**. Thereafter, the aircraft **104** may go through certification and delivery **114** in order to be placed in service **116**. While in service by a customer, the aircraft **104** may be
15 scheduled for routine maintenance and service **118** (which may also include modification, reconfiguration, refurbishment, and so on).

Each of the processes of method **102** may be performed or carried out by a system integrator, a third party, and/or an operator (e.g., a customer). For the
20 purposes of this description, a system integrator may include without limitation any number of aircraft manufacturers and major-system subcontractors; a third party may include without limitation any number of vendors, subcontractors, and suppliers; and an operator may be an airline, leasing company, military entity, service organization, and so on.

25 As shown in FIG. **22**, the aircraft **104** produced by exemplary method **102** may include an airframe **120** with a plurality of systems **122** and an interior **124**. The disclosed method and apparatus may be employed to fabricate frame sections and stiffeners which form part of the airframe **120**. Examples of high-level systems **122**

include one or more of a propulsion system **126**, an electrical system **128**, a hydraulic system **130**, and an environmental system **132**. Any number of other systems may be included. Although an aerospace example is shown, the principles of the invention may be applied to other industries, such as the automotive industry.

5

The apparatus embodied herein may be employed during any one or more of the stages of the production and service method **102**. For example, components or subassemblies corresponding to production process **110** may be fabricated or manufactured in a manner similar to components or subassemblies produced while
10 the aircraft **104** is in service. Also, one or more apparatus embodiments may be utilized during the production stages **110** and **112**, for example, by substantially expediting assembly of or reducing the cost of an aircraft **104**. Similarly, one or more apparatus embodiments may be utilized while the aircraft **104** is in service, for example and without limitation, to maintenance and service **118**.

15

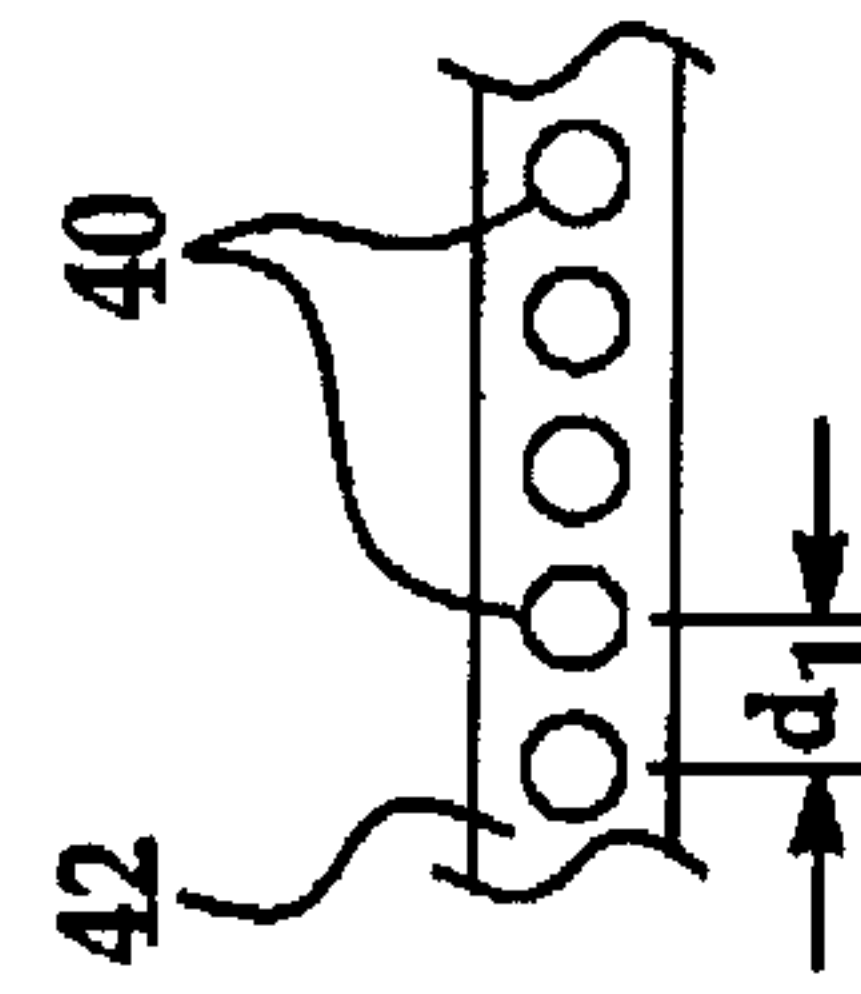
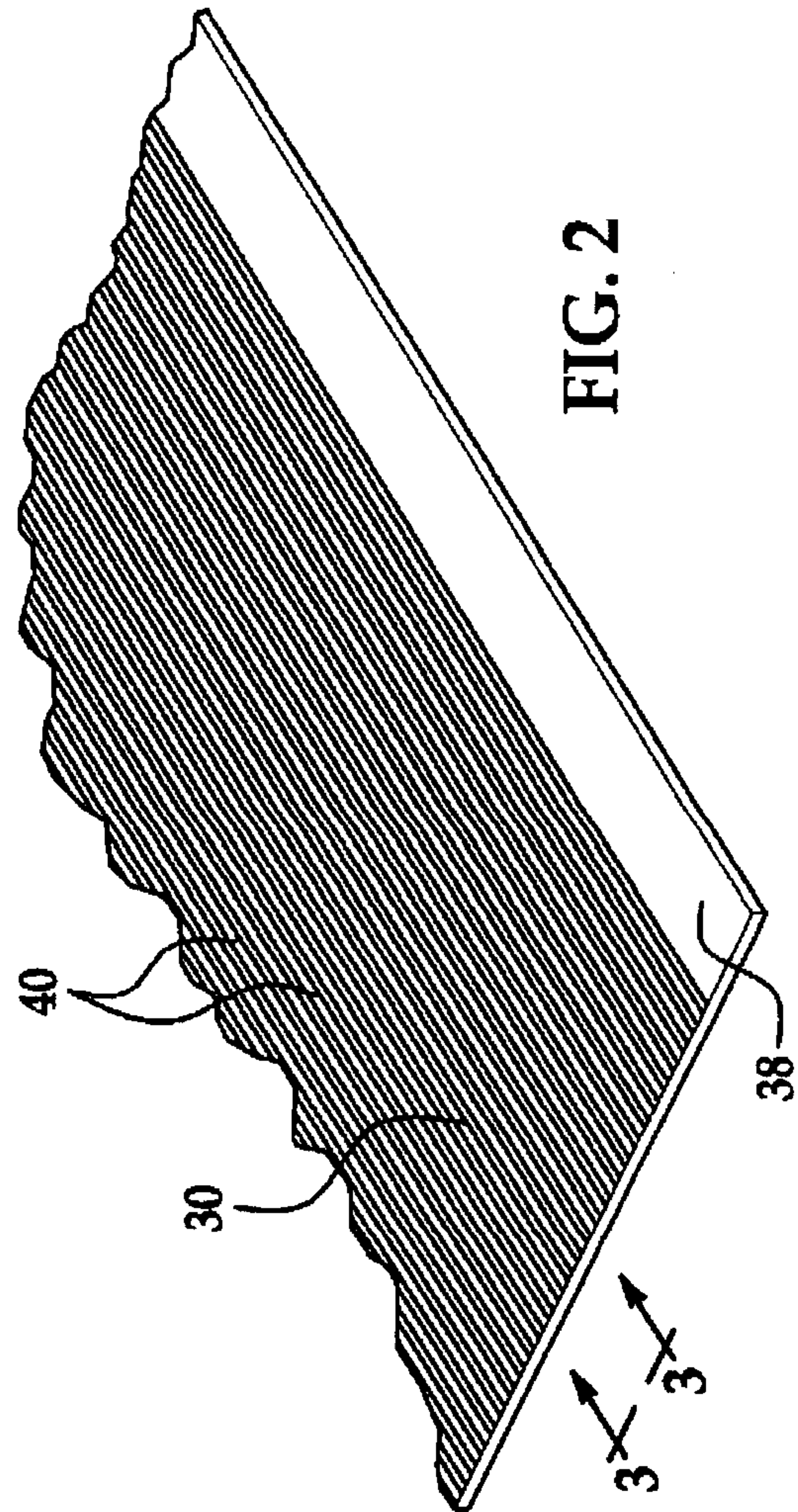
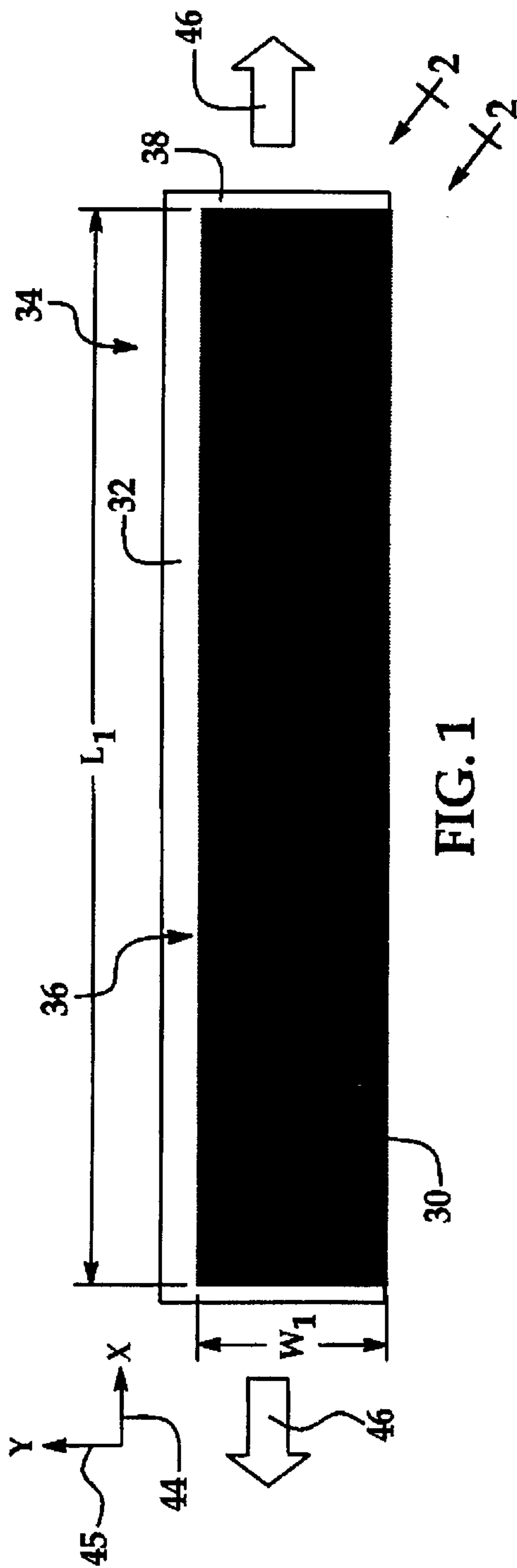
Although the embodiments of this disclosure have been described with respect to certain exemplary embodiments, it is to be understood that the specific embodiments are for purposes of illustration and not limitation, as other variations will occur to those of skill in the art.

20

**THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

- 5 **1.** A method of deforming a prepreg fiber ply, comprising:
- laying up a unidirectional prepreg fiber ply on a film; and
- deforming the film with the ply thereon.
- 10 **2.** The method of claim **1**, wherein deforming the film includes stretching the film
in a direction traverse to the orientation of the fibers in the ply.
- 15 **3.** The method of claim **1**, further comprising restraining at least a portion of the
film against deformation.
- 4.** The method of claim **3**, wherein restraining at least a portion of the film
against deformation is performed by reinforcing the portion of the film.
- 20 **5.** A prepreg fiber ply deformed by the method of claim **1**.

1/8



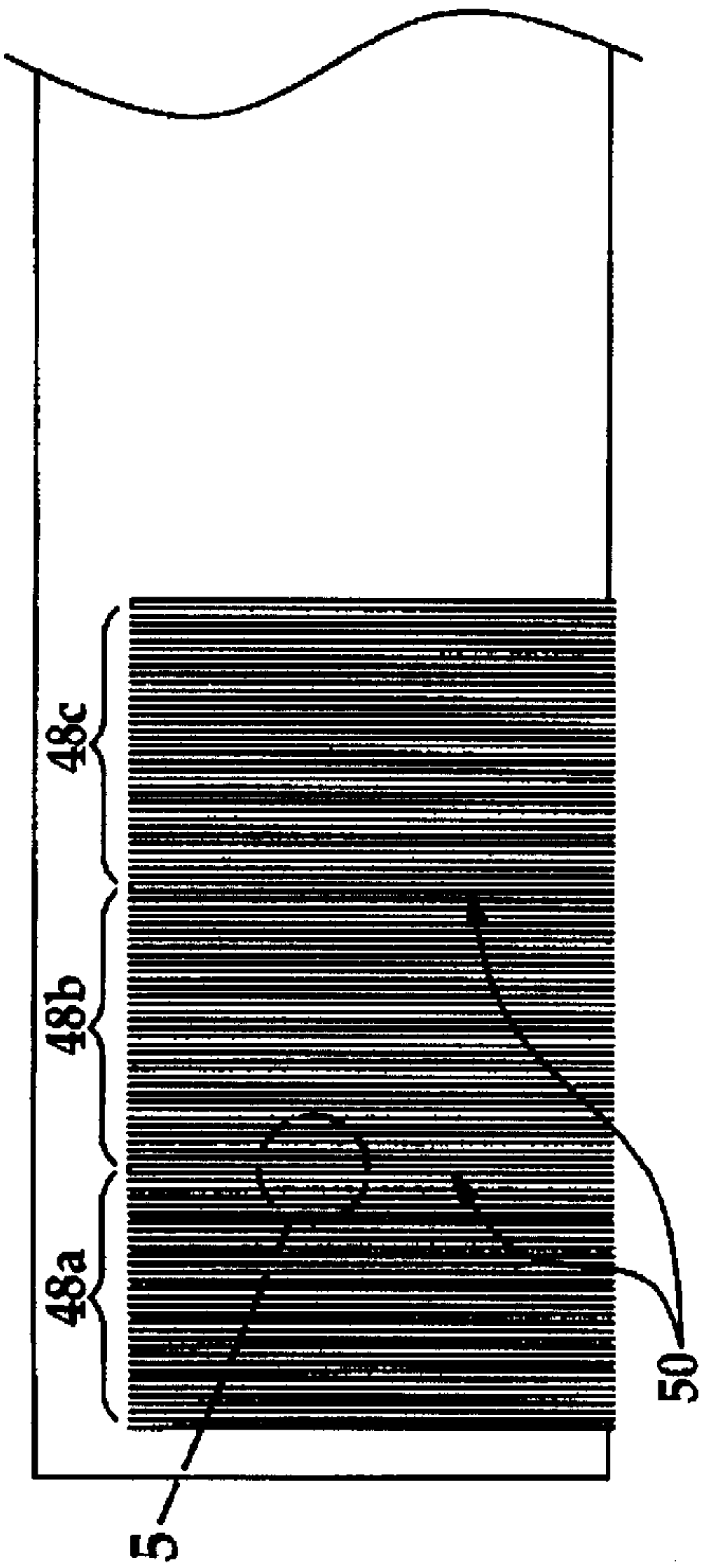


FIG. 4

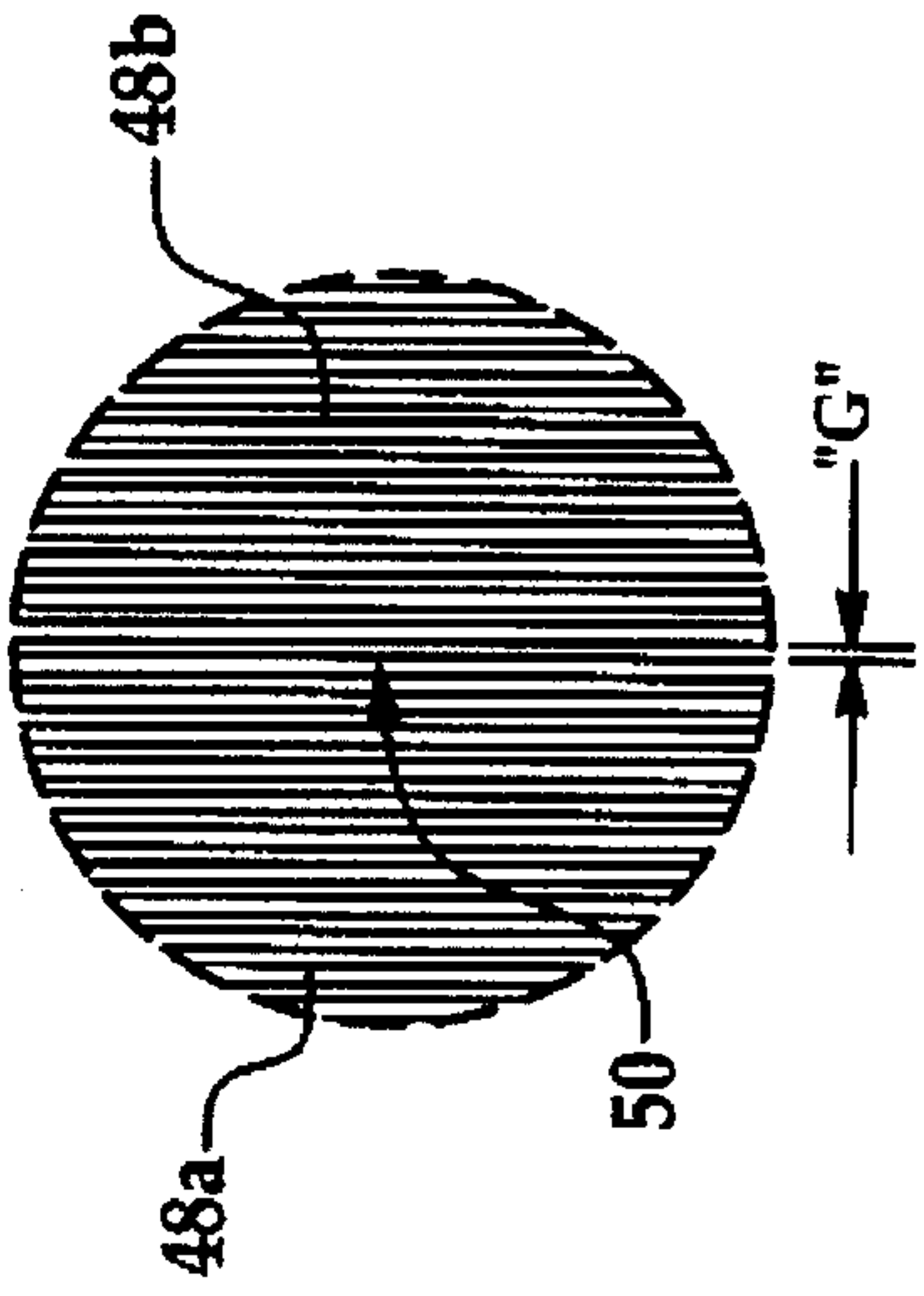


FIG. 5

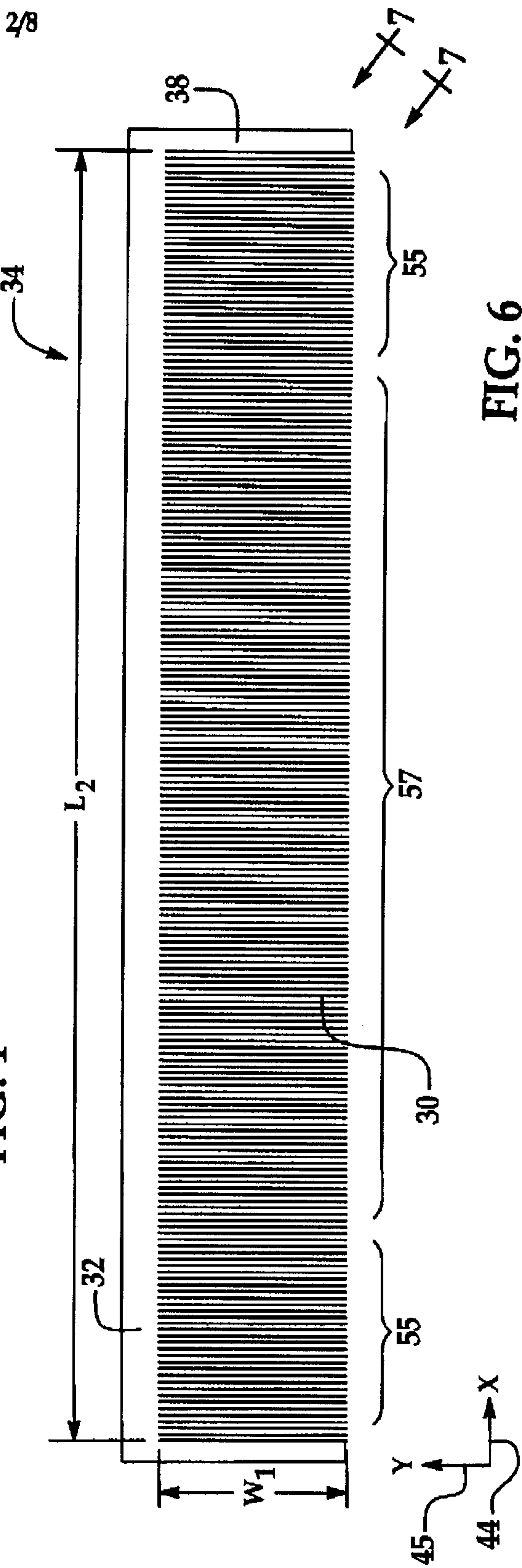


FIG. 6

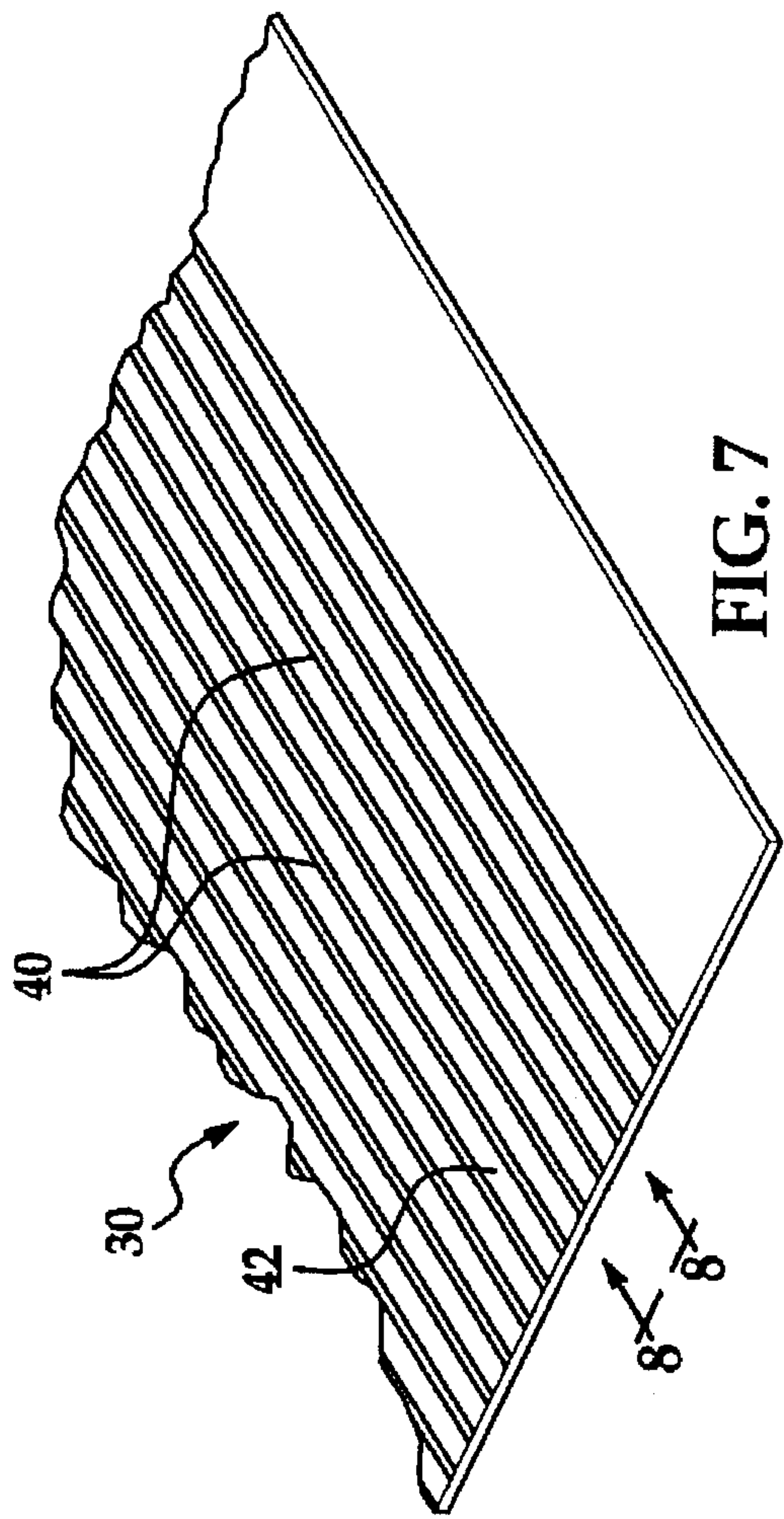


FIG. 7

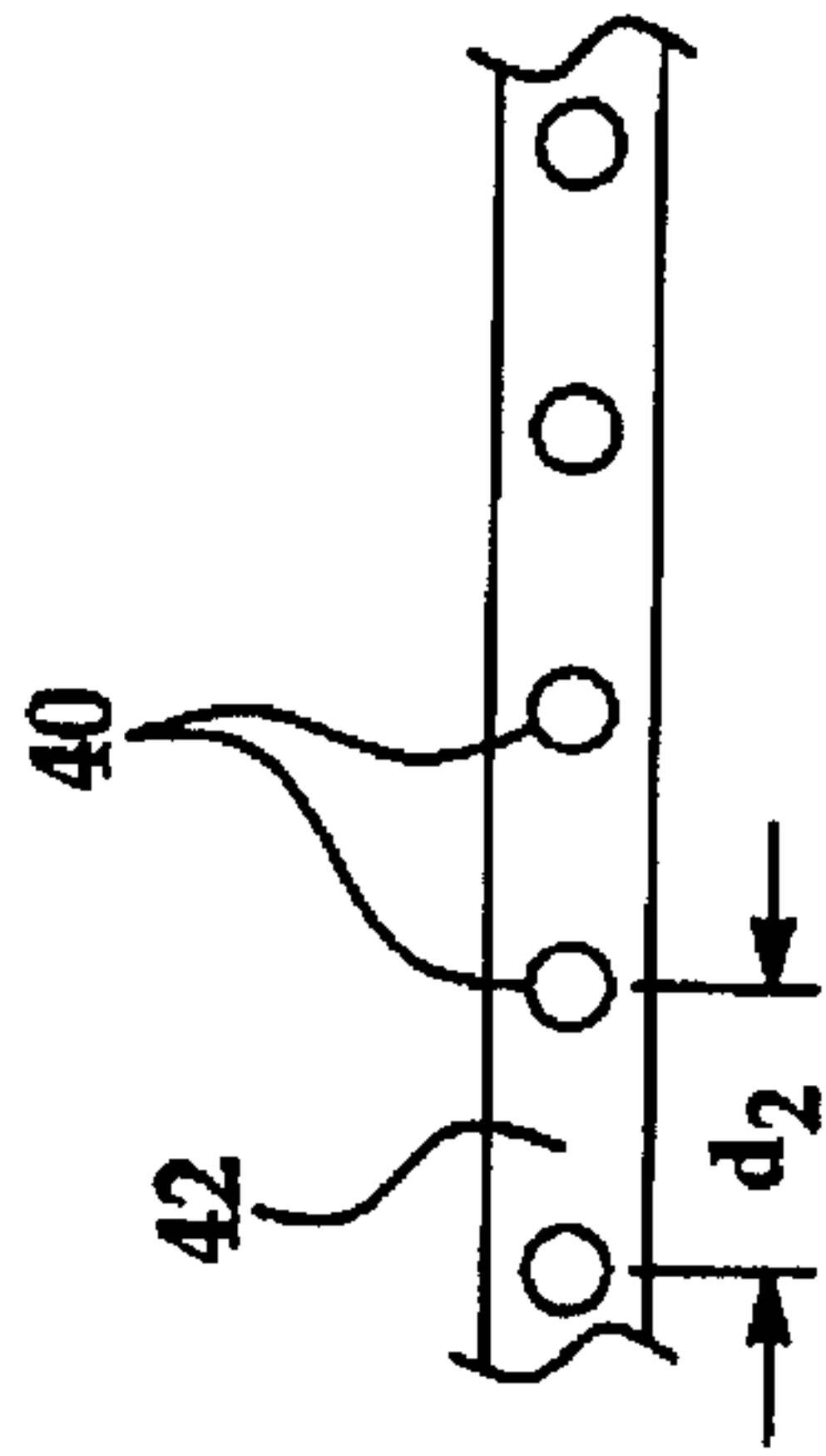


FIG. 8

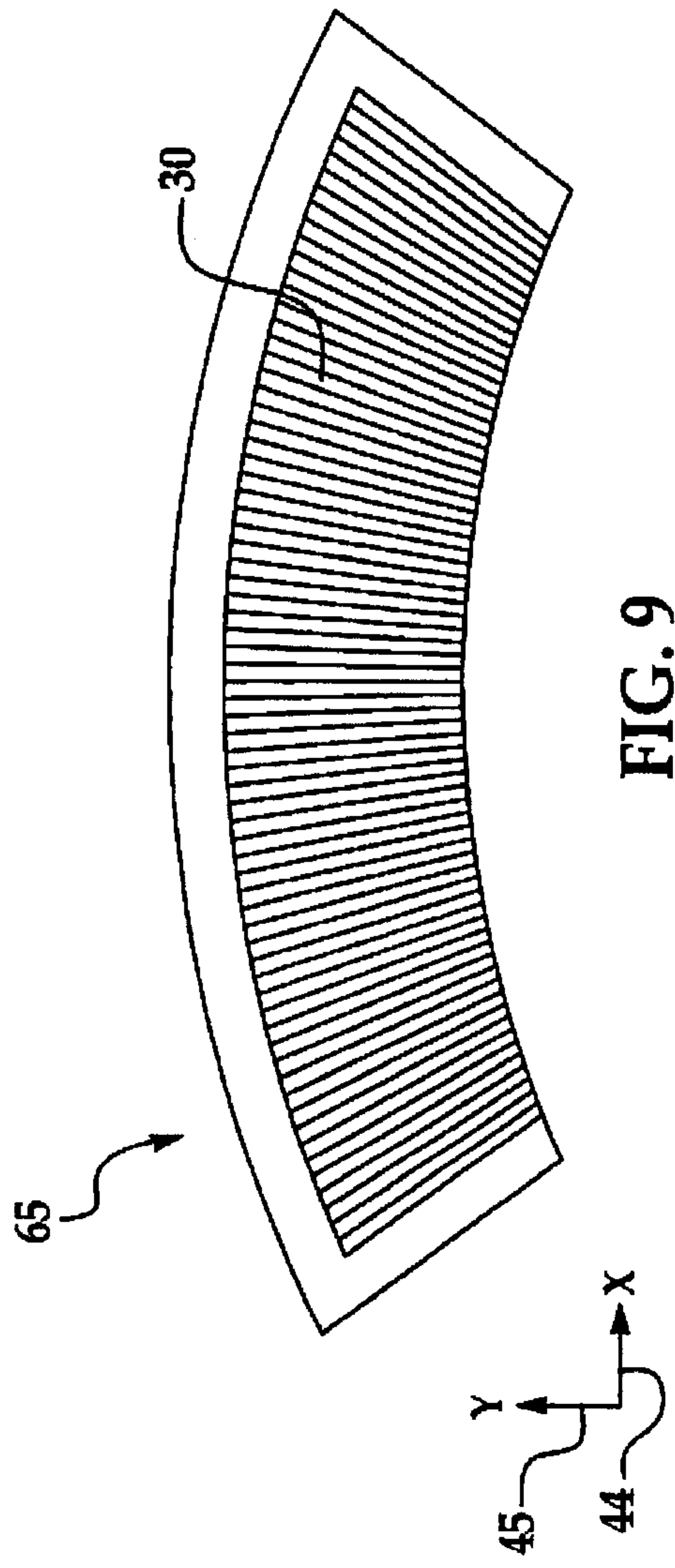


FIG. 9

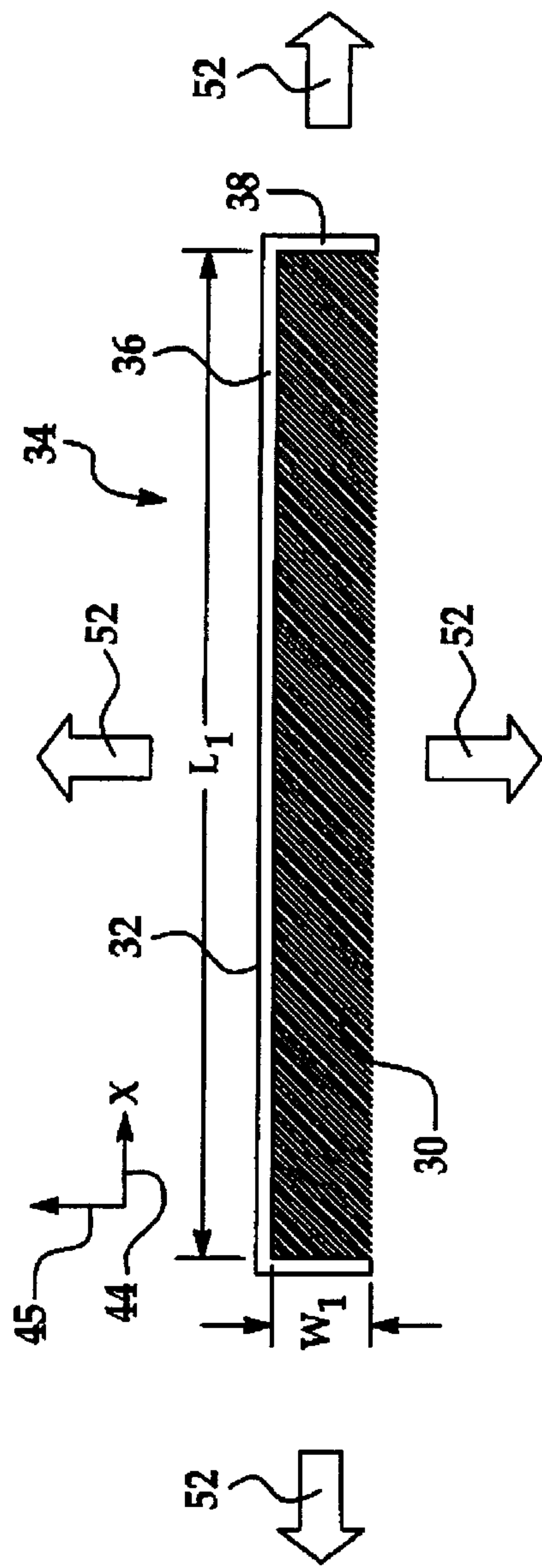


FIG. 10

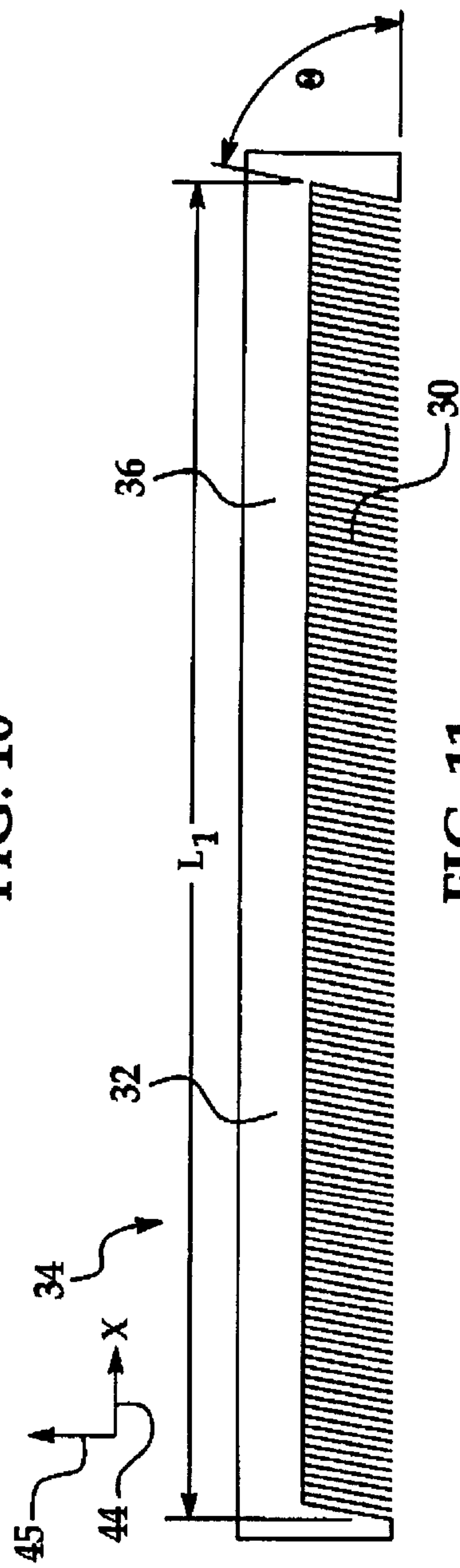


FIG. 11

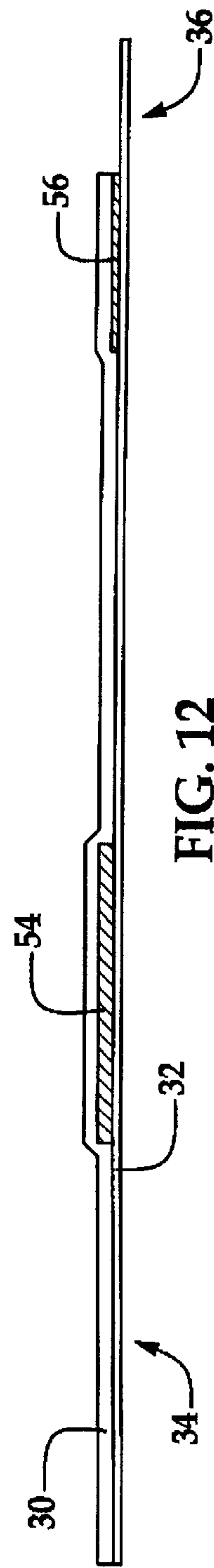


FIG. 12

5/8

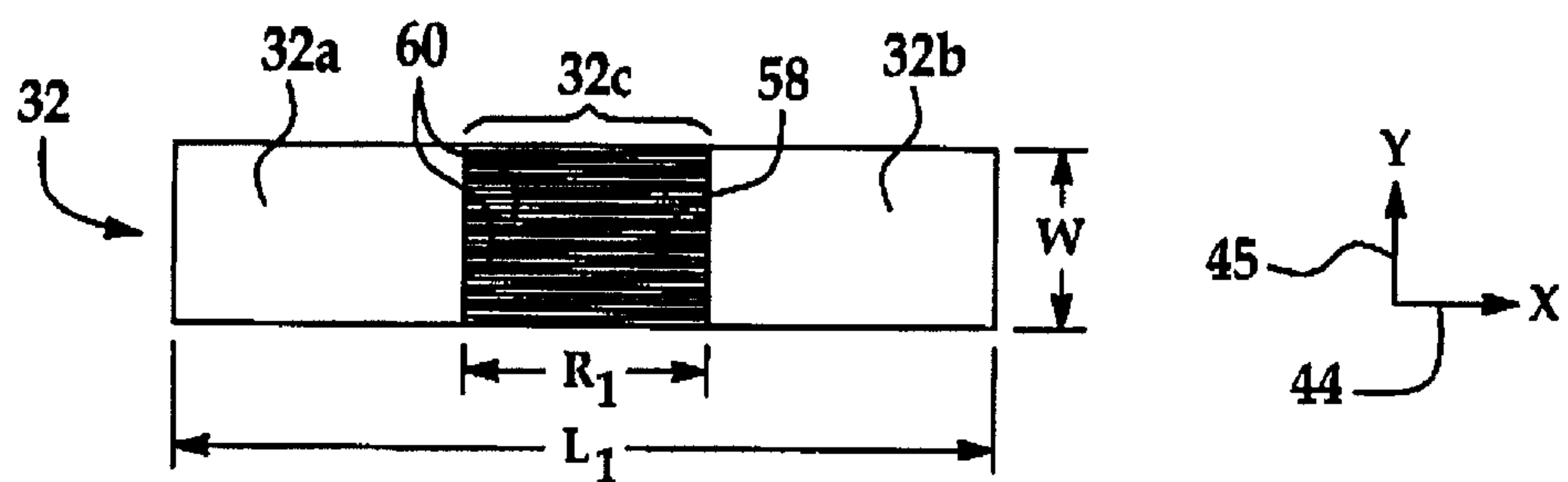


FIG. 13

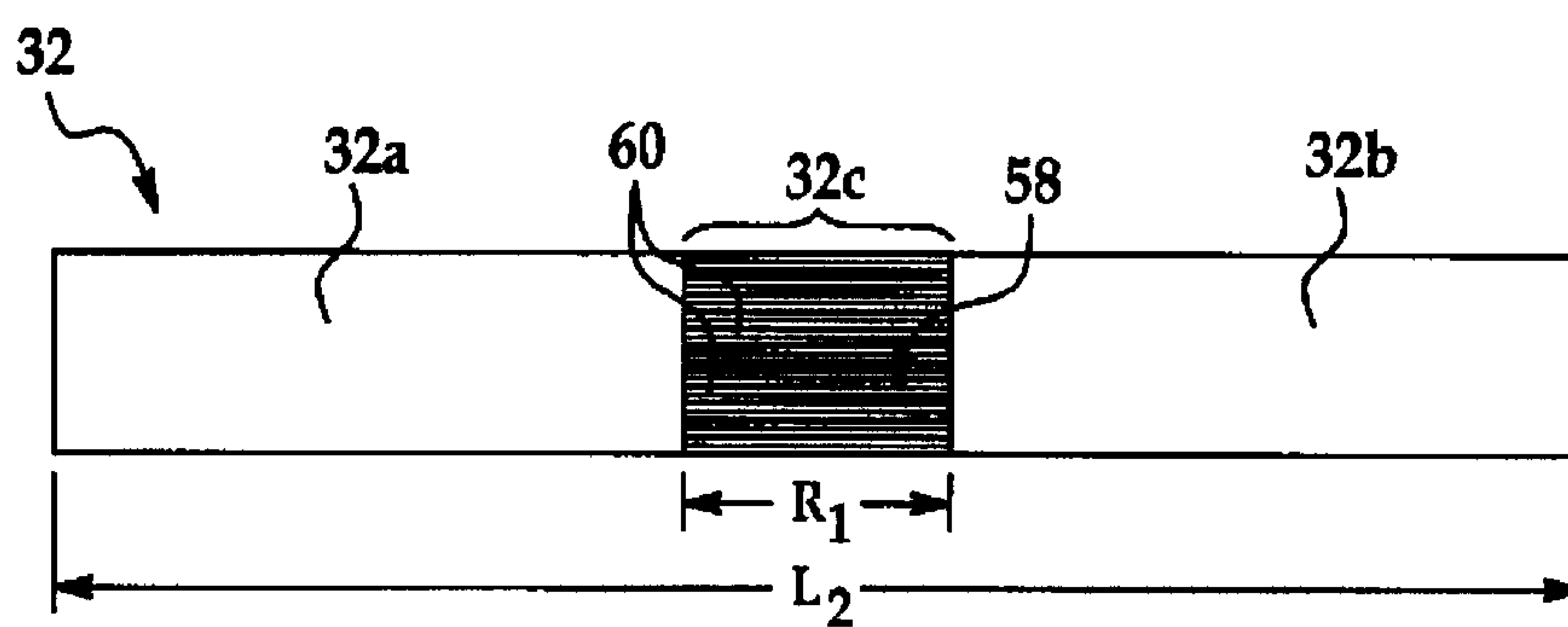


FIG. 14

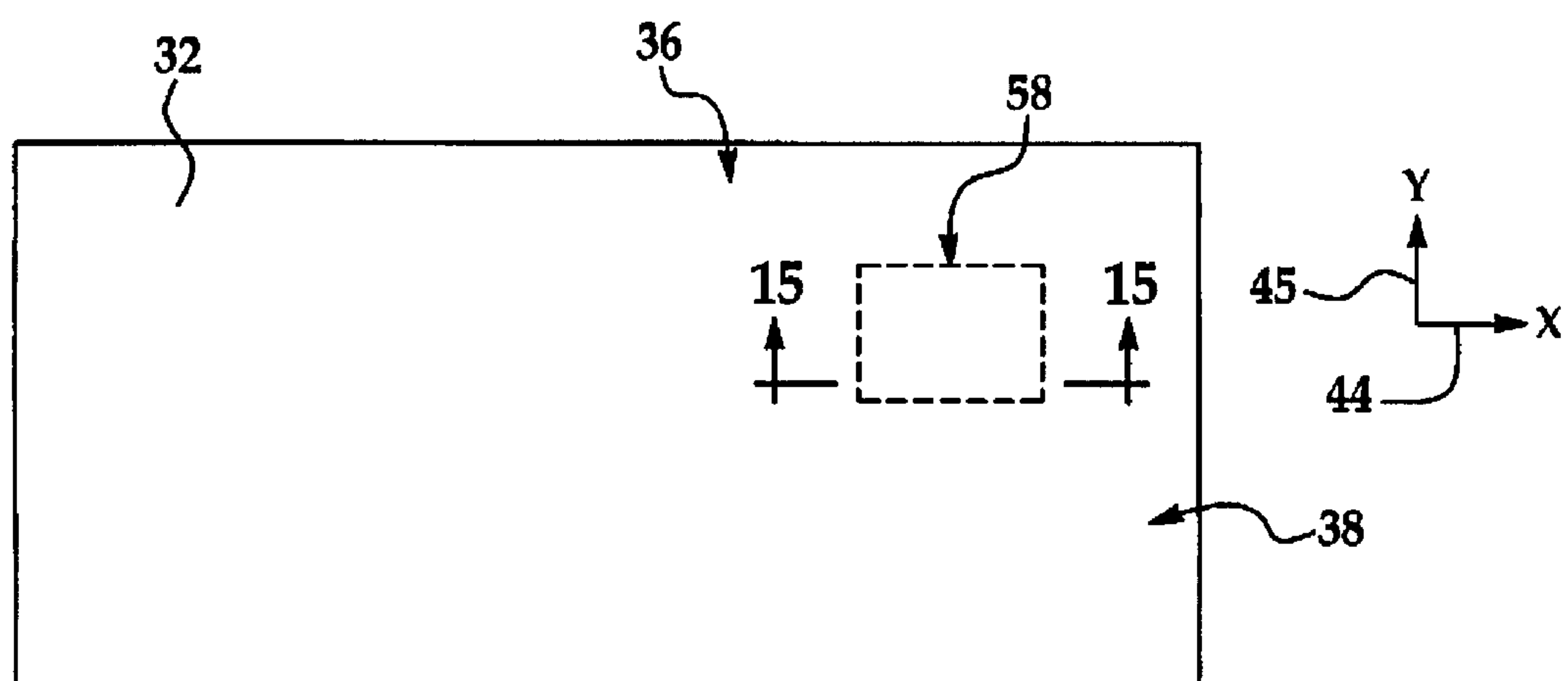


FIG. 15

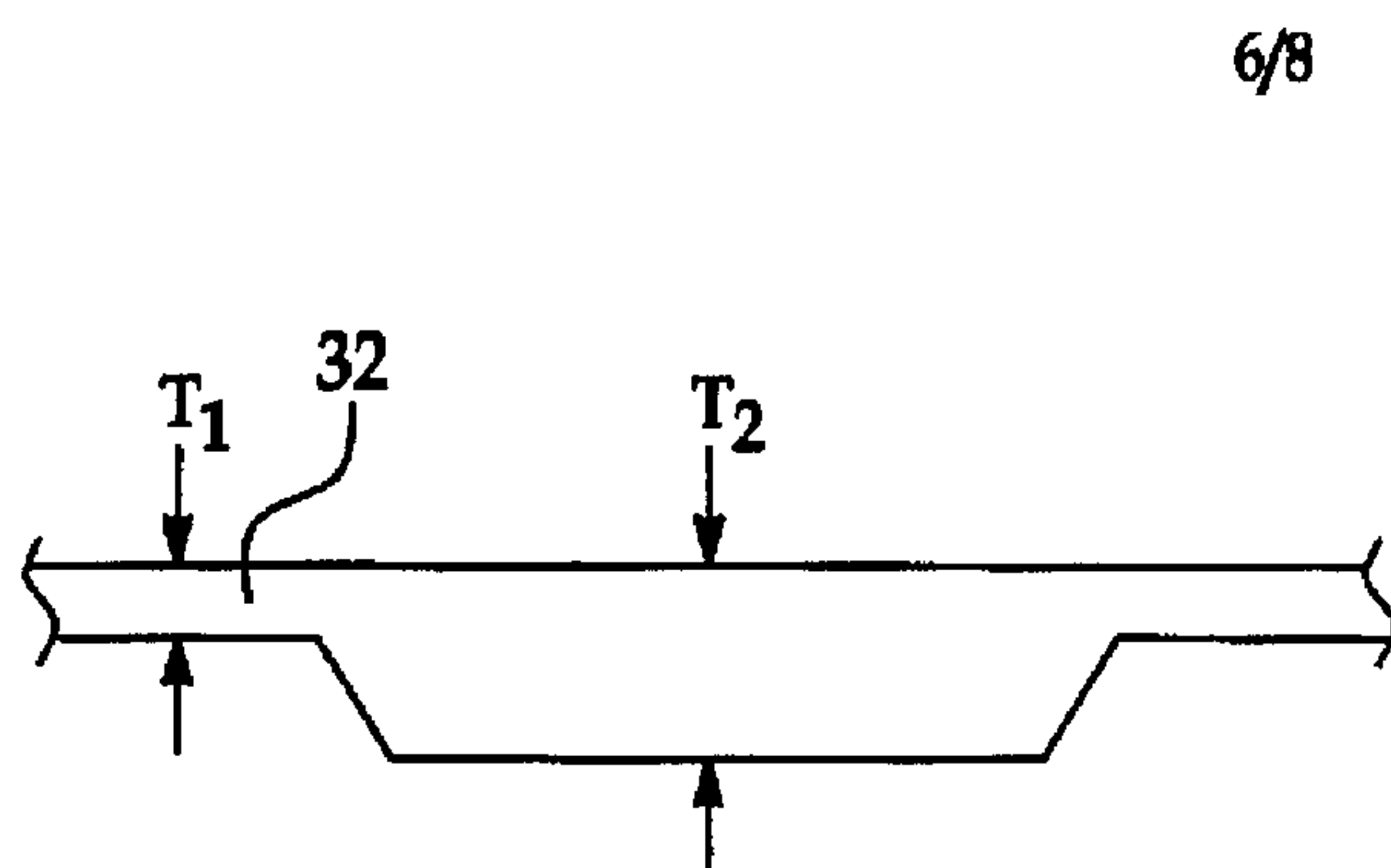


FIG. 16

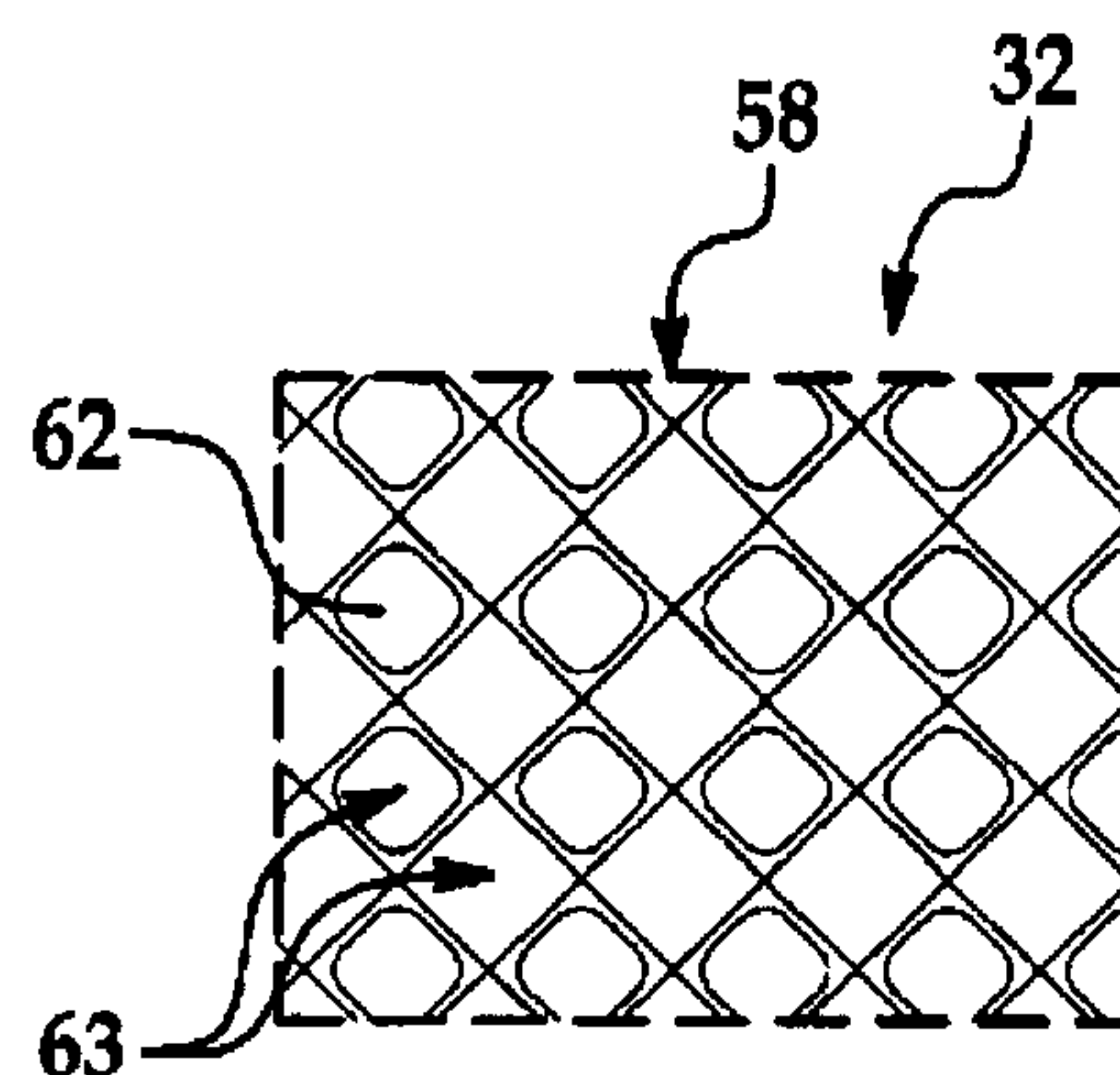


FIG. 17

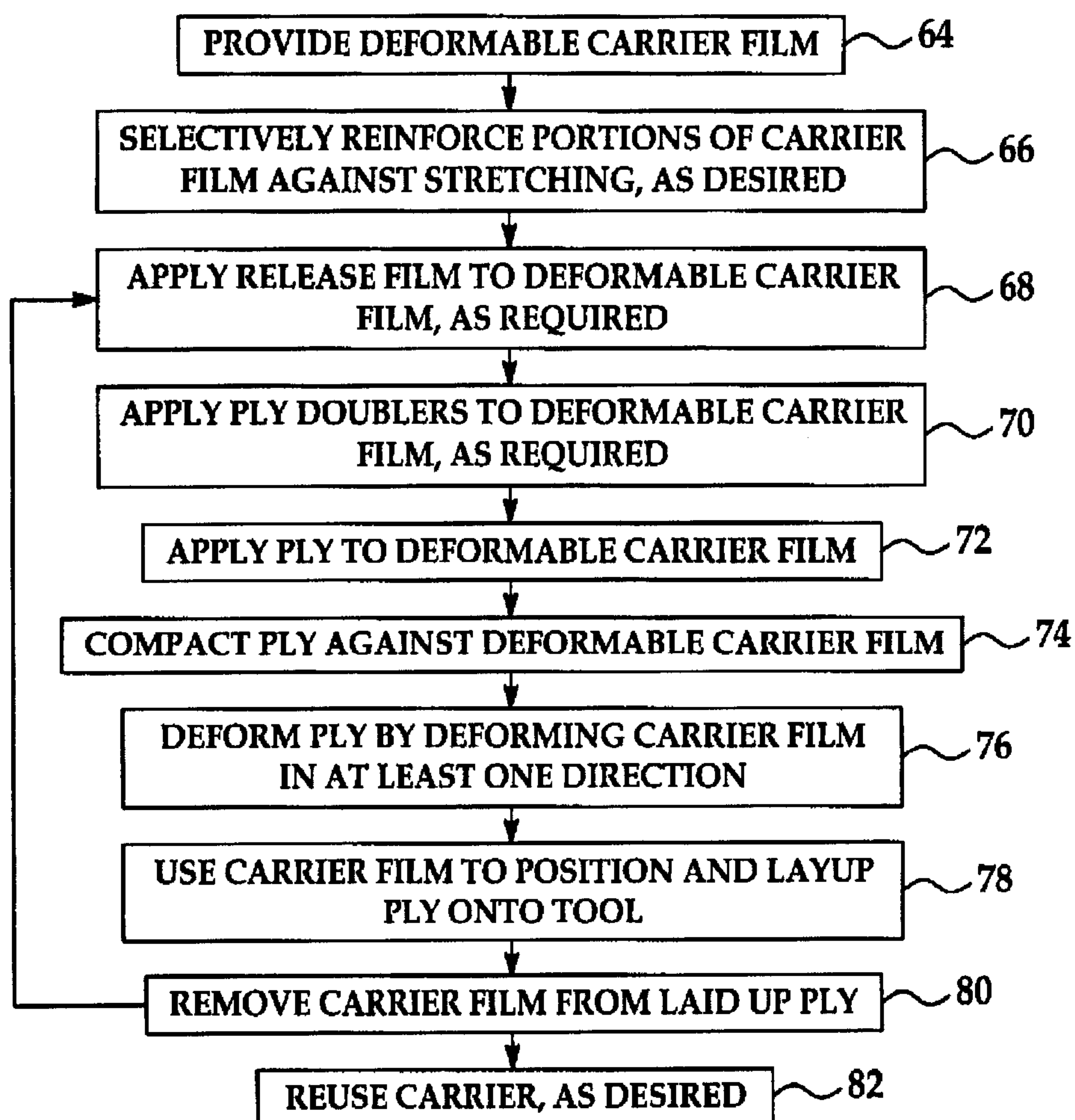


FIG. 18

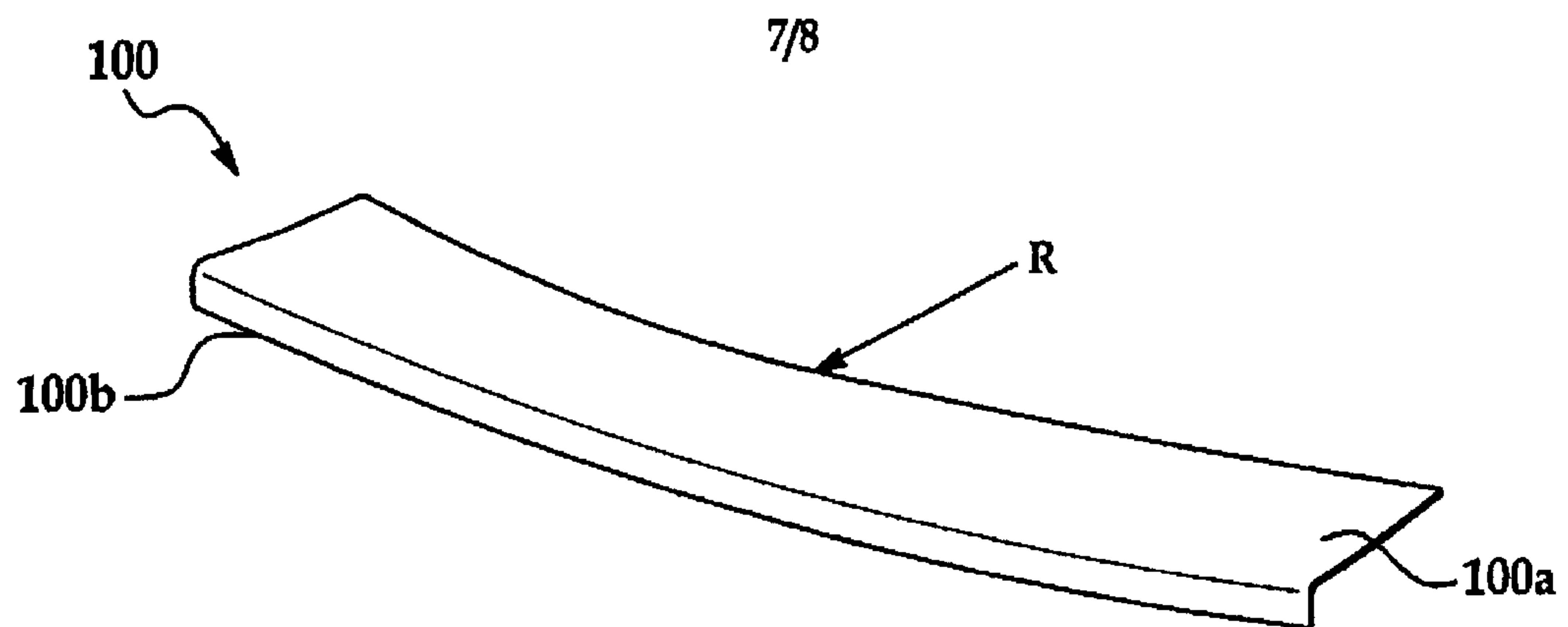


FIG. 19

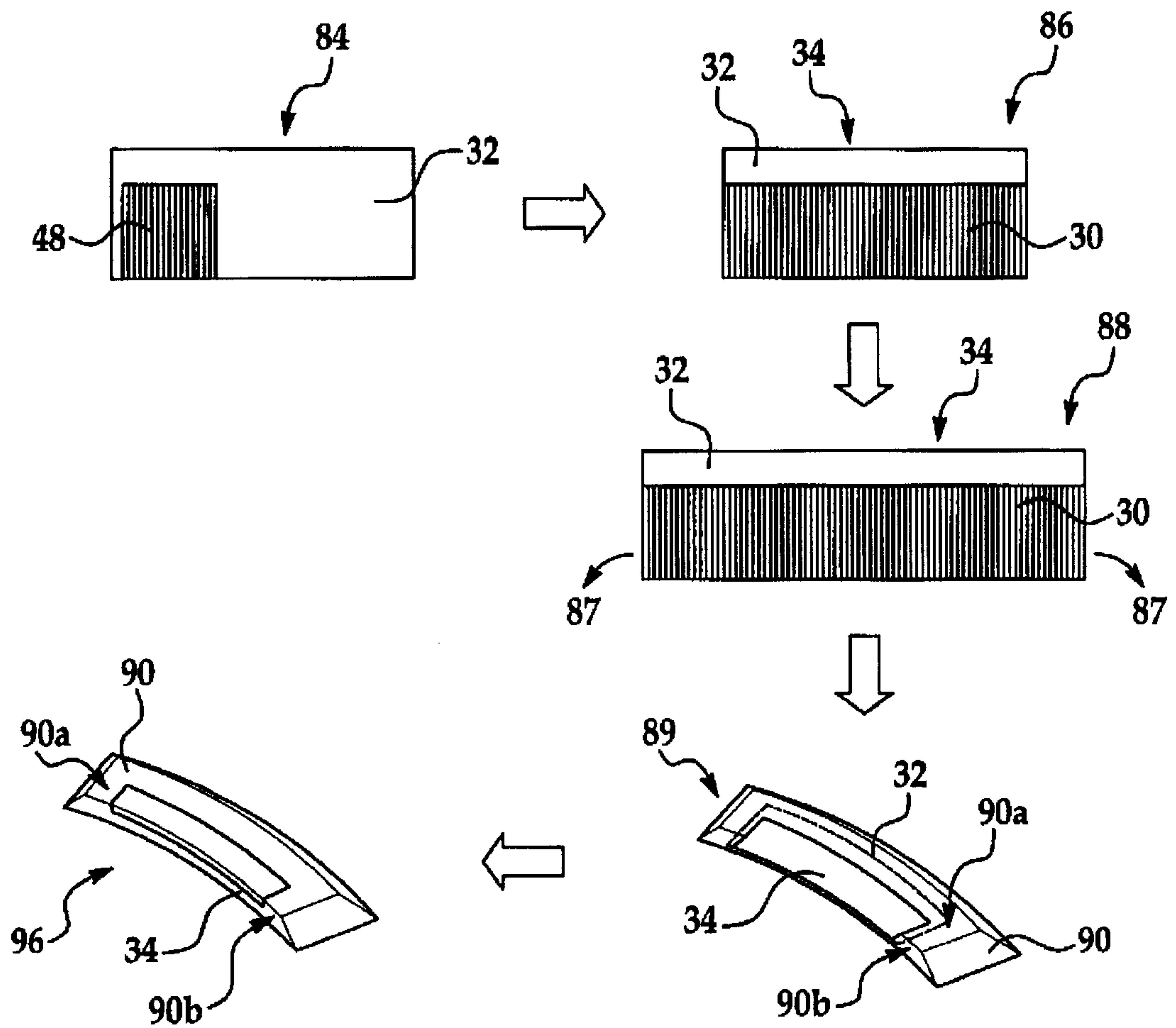


FIG. 20

8/8

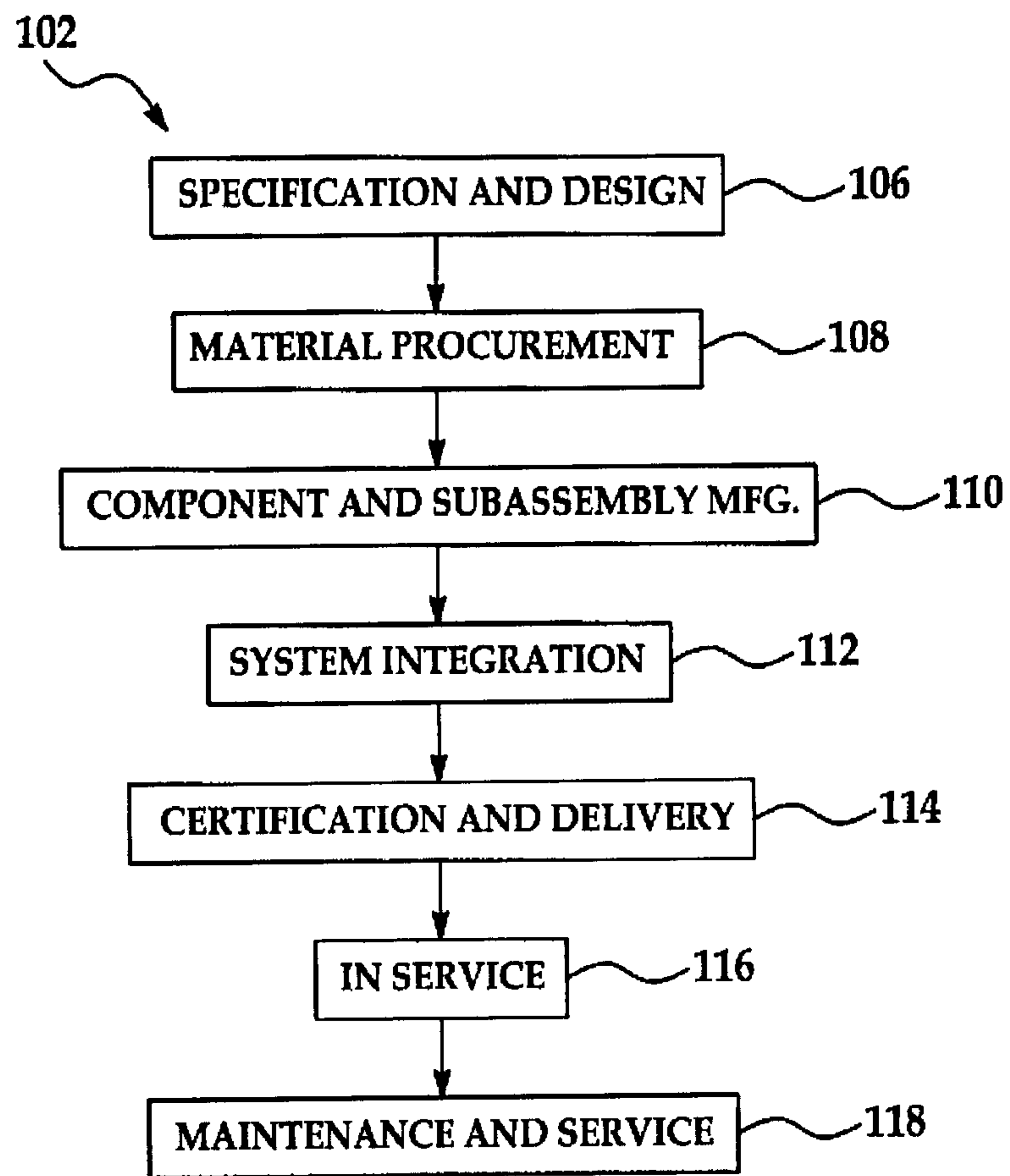


FIG. 21

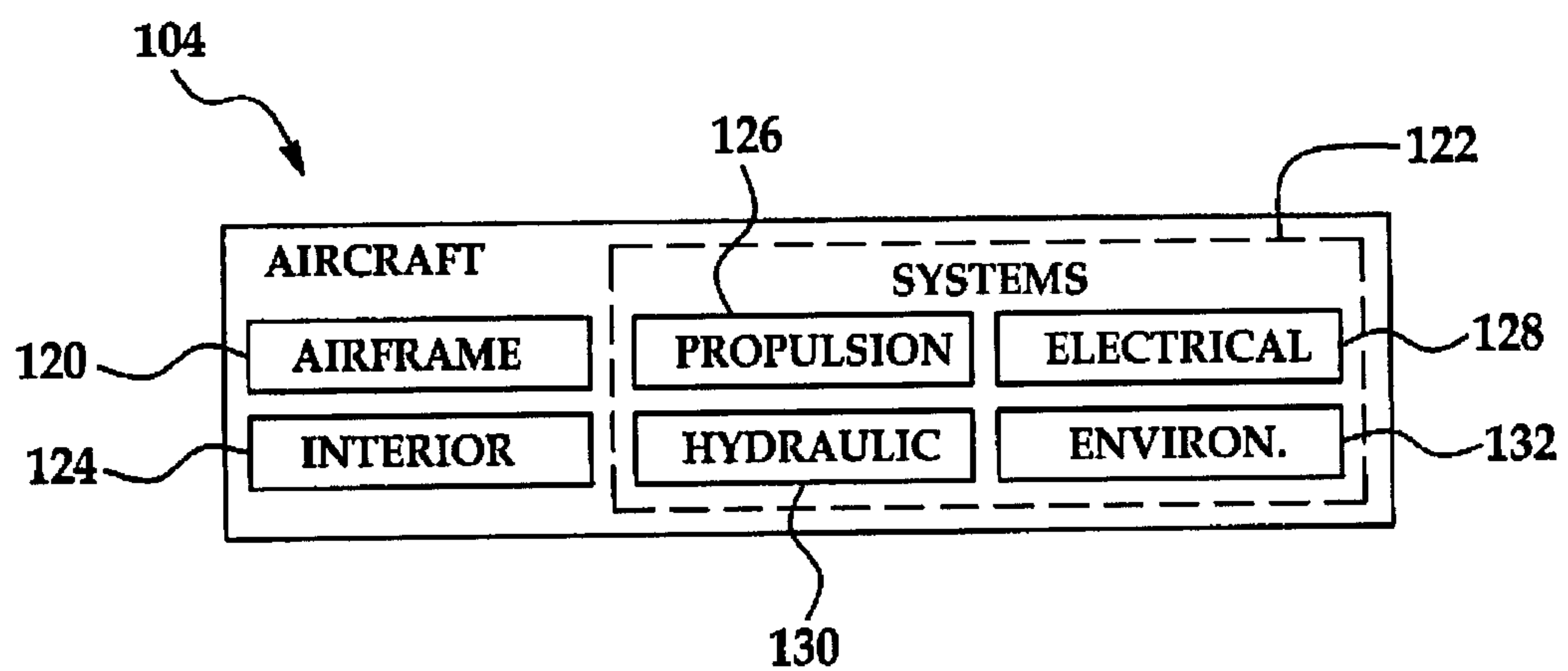


FIG. 22

PROVIDE DEFORMABLE CARRIER FILM

64

**SELECTIVELY REINFORCE PORTIONS OF CARRIER
FILM AGAINST STRETCHING, AS DESIRED**

66

**APPLY RELEASE FILM TO DEFORMABLE CARRIER
FILM, AS REQUIRED**

68

**APPLY PLY DOUBLERS TO DEFORMABLE CARRIER
FILM, AS REQUIRED**

70

APPLY PLY TO DEFORMABLE CARRIER FILM

72

COMPACT PLY AGAINST DEFORMABLE CARRIER FILM

74

**DEFORM PLY BY DEFORMING CARRIER FILM
IN AT LEAST ONE DIRECTION**

76

**USE CARRIER FILM TO POSITION AND LAYUP
PLY ONTO TOOL**

78

REMOVE CARRIER FILM FROM LAID UP PLY

80

REUSE CARRIER, AS DESIRED

82

